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ORDER AND DISORDER IN PURE LIQUIDS AND SOLUTIONS[1]

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THE only fault I can find with an occasion such as his is its effect upon my character; I shall doubtless merge shorn of every shred of modesty I may have possessed on arrival. You will hardly expect me, however, not to feel, and therefore to express, several sources of satisfaction. I am, of course, greatly honored, not only by the action of the Jury of Award, but also by the presence this evening of so many fellow chemists, former students and old friends. Again, my heart is warmed by the kind things that have been said of me by Dr. Harned and Dr. Eyring. Harned was my first research student, and we did together the first work published in this country on the use of the hydrogen electrode to follow the course of a chemical reaction. I can claim only this credit for his subsequent notable scientific career that I did not spoil his natural instinct for research. As for Eyring, I claim a little credit for having helped to create the bracing atmosphere which he breathed as a graduate student in Berkeley and much more credit for having urged him to take the plunge into the liquid state which has resulted in his bringing up some brilliant results.

Further satisfaction is lent by the fact that the award of the Nichols medal is based upon having stimulated research. The problems involved in the theory of solubility are so numerous and complex that it became evident long ago that to catalyze their solution on a broad scale would be a finer achievement than to cultivate only a little of the large field which, years

[1] William H. Nichols Medal Address before the New York Section of the American Chemical Society, March 9, 1939.

ago, only a few of us occupied. I have endeavored, therefore, to analyze the problems, to point out the main hurdles that I was not equipped, myself, to surmount, and to gather the kind of data which would provide honest and crucial tests for any theories, whether my own or those of others.

It is highly gratifying, therefore, to see to-day a wide-spread interest in the liquid state and a number of brilliant investigators devoting attention to it. Symposia on liquids and solutions held recently by the Faraday Society and by our own division of physical and inorganic chemistry have been truly exciting. In my discussion this evening of "Order and Disorder in Pure Liquids and Solutions," I am presenting ideas credit for which I am pleased to share with a number of others, including Bernal, Butler, Debye, Eyring, Fowler, Guggenheim, Kirkwood, Lennard-Jones, London, Menke, Prins, O. K. Rice, Scatchard, G. W. Stewart and, I am eager to add, my own young collaborators.

In discussing order and disorder we shall find it convenient to make frequent use of the term "entropy," a word which is sometimes a bit terrifying. A student once asked me, "What is entropy?," saying that his instructor in engineering thermodynamics had answered that question by saying that "nobody understands entropy, you just use it." Now as a matter of fact, that is rather a gloomy view, and I should like, for my purposes, to review the background of this concept in a very elementary way. Entropy is a term occurring, as you know, in certain thermodynamic equations to account for the fact that heat can not be transformed quantitatively into work, and kinetic theory indicates that it is rather simply related to molecular disorder. The amount of disorder depends upon the number of possible arrangements. In a pure, monatomic, crystalline solid at absolute zero there is no disorder, and therefore no entropy. The molecules are in the position of checkers on a board whose spaces just fit them. However, a solid solution, say of two isotopes, would have entropy, due to the fact that there are a great many ways in which molecules of the two species might be arranged. It comes out that the entropy change in forming a mole of solution from its pure crystalline components is

$$-R(N_1 \ln N_1 + N_2 \ln N_2),$$

where N_1 and N_2 are their respective mole fractions in the solution.

As a pure solid is heated, it is as if the squares on the checkerboard increased in size, and the pieces, although remaining within the squares, could acquire a certain degree of disorder. Melting would correspond roughly to abolishing the squares, so that a given piece could be anywhere on the board where it could find space with, consequently, a considerable increase in the possibilities of disorder. Vaporization would correspond to spilling the checkers over a large floor space, where a given piece could be almost anywhere within the area, and the possible disorder dependent on the available area, diminished only by the relatively insignificant space occupied by the pieces themselves. The change of entropy of a dilute gas in expanding from V_1 to V_2 is $R \ln \frac{V_2}{V_1}$, *i.e.*, it is a function of volume only.

Let us return now to a closer examination of the degree of order existing in liquids, and begin with the simplest cases—those liquids whose molecules are effectively spherical. A crude model for such liquids could be a number of tennis balls in a box about 25 per cent. larger than the minimum that would hold them, and violently agitated by vibrating walls. Such an assemblage may be assumed to be in the maximum permitted state of disorder.

If instead of tennis balls we should use sausage-shaped balloons, a certain amount of order would be imposed solely by the fact that the balloons would tend to arrange themselves in parallel array. Again, if each ball or balloon, as the case might be, had a magnet somewhere just beneath the surface, these magnets would encourage some degree of order, however small. Since there are many substances whose molecules are linear, such as carbon dioxide and pentane, or flat, like benzene, we may suspect their liquids of some degree of order. The presence of electric dipoles in molecules such as ethyl iodide should have a similar orienting effect. Any chemical combination should likewise reduce the amount of disorder.

Now there are at least two distinct kinds of evidence available concerning orderly arrangement in the liquid state, one, the well-known diffraction of x-rays, the other, which I am presenting here for the first time, the change in entropy on vaporization. I shall deal first with the latter. All chemists are doubtless familiar with a useful rule discovered long ago by Trouton, which states that the heat of vaporization per mole divided by the boiling point on the absolute scale has the same value, about 21 cals. per degree, for a large number of liquids which we have come to distinguish as "normal." This quotient turned out to be not a constant but to have a slow upward drift with increasing boiling point. Several investigators published empirical formulas to take this into account. In 1915 I noted that a graphic plot of the logarithm of vapor pressure against the logarithm of absolute temperature, as in Fig. 1, indicated that the entropy of vaporization, which is given by the slope of the tangent to such a curve, is approximately the same if the liquids are compared, not at their boiling points, where the pressures are the same, but at temperatures

so selected that the final volume of vapor is always the same. This substitute for Trouton's rule is a rather good approximation for normal liquids all the way from nitrogen to silver. We can perhaps see why equal volumes rather than equal pressures should be chosen simply by inspecting the thermodynamic equation, $\Delta S = \Delta V(dp/dT)$. The value of ΔS depends in part upon ΔV, which in turn depends mainly upon the volume of the vapor.

Since all normal vapor pressure curves, when plotted as in Fig. 1, can be superimposed by sliding along a

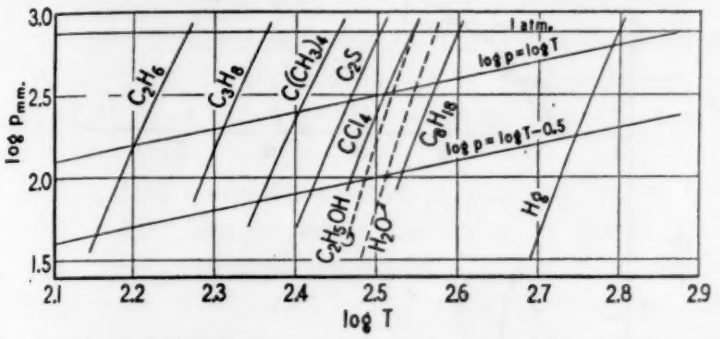

FIG. 1. Uniformity of entropy of vaporization of normal liquids at identical vapor concentration.

line of unit slope, we need only a single point, such as the boiling point, to enable us to draw a good approximation to the entire vapor pressure curve.

This rule should, of course, be true only for liquids in which there is the same amount of disorder. One way to insure this is to compare liquids in which the disorder is a maximum, which should be the case with liquids whose molecules are spherically symmetrical. Such molecules, however, are in the minority. More numerous are those which, as suggested above, have geometrical shapes tending to pack in some sort of ordered array. Still others are electrically polar and this also gives rise to more or less orientation. Now both of these effects show up quite clearly in increasing the entropy of vaporization to constant volume. Table 1 gives the entropy of vaporization at a concentration arbitrarily chosen as 0.0153 moles per liter, corresponding to $\log Rc = 0.1$, together with the excess of each over the value for neopentane, a substance whose structure is so symmetrical that it has been selected as a standard of reference for all the others. Let us notice first the figures for the three isomeric pentanes.

TABLE I

STRUCTURAL ENTROPY OF LIQUIDS

Hg	0.0	CCl_4	0.6
$C(CH_3)_4$	0.0	$SiCl_4$	1.1
i–C_5H_{12}	0.1	$SnCl_4$	1.7
n–C_5H_{12}	0.6	$C(NO_2)_4$	2.5
n–C_6H_{14}	1.4	C_6H_6	1.1
n–C_7H_{16}	1.4	C_6H_{12}	1.0
n–C_8H_{18}	1.1	$(C_2H_5)_2O$	1.7
i–C_6H_{14}	0.2	$(CH_3)_2CO$	2.4
(Di-isopropyl)		C_2H_5OH	6.9

The isopentane, with its branched chain, shows a slight excess, while the linear normal pentane shows a much larger excess, 0.6. Going to longer hydrocarbons, with their greater orienting effect, we see a still further increase, while comparing hexane with its much more symmetrical isomer, di-isopropyl, we see a drop from 1.4 to 0.2.

Carbon tetrachloride, although tetrahedral and rotating, has been shown by Menke through x-ray scattering to have some slight degree of structure and in harmony with this we find an excess entropy of 0.6 unit. Silicon and tin tetrachlorides, with their progressively larger, more open structures, show further increases to 1.1 and 1.7, respectively. Tetra-nitro-methane, with distortable nitro groups, shows evidence of still more structure.

Benzene and cyclohexane are free from dipole moment, but their flat rings are doubtless responsible for a marked degree of structure. Their rather high freezing points may be regarded as contributory evidence.

Ether has a moderate dipole, but this is fairly well buried, as shown by the fact that its electric polarization in solution varies only slightly with concentration. In harmony with this, its entropy of vaporization gives evidence of only moderate structure, for which its geometrical form is doubtless to a large degree responsible. To vaporize acetone, which has a larger and more exposed dipole, involves a much greater increase in entropy. Ethyl alcohol shows a greatly enhanced value due to the hydrogen bonds which give the liquid a pronounced structure, confirmed by x-ray scattering. We shall see later that each of these three sources of structure may influence the entropy changes occurring when different liquids are mixed.

The evidence then for the non-polar liquids in Table I indicates that most of them possess some degree of structure and are, therefore, not completely normal in the sense of possessing the most complete randomness of molecular distribution. It is true that if we omit neopentane and mercury, a number of others would differ but to a small extent from their mean value. It is only when we select the comparatively rare substances possessing complete symmetry that we bring to light the different degrees of approach to so-called normal behavior. My colleague, Dr. Pitzer, proposes, quite appropriately, to call liquids such as neopentane "perfect liquids." The fact that perfect liquids are rare does not destroy the usefulness of the concept. Ideal cases are almost as rare in physical science as in human behavior, but whenever a number of instances occur in which the departure from the ideal are small, as with normal liquids, it pays to analyze the implications of the ideal and thus approach more or less closely to an understanding of the actual cases.

What we have called completely random liquid structure does indeed possess a certain kind of structure,

due to the fact that no two molecules can occupy the same space simultaneously. Their centers must always remain about one molecule diameter apart. If, therefore, we consider the distribution of molecular centers around any one molecule selected as an origin for polar coordinates, we may imagine a series of thin concentric shells of thickness dr and radius r from the central molecule, as in Fig. 2. It is evident that no such shell could contain any molecular centers until r equaled the molecular collision diameter, which would, of course, vary slightly with the force of the collision and therefore with the temperature. As r increases, the number of molecular centers in a shell would go through a minimum and reach a second maximum when a second layer of molecules is reached. This maximum would, of course, be less pronounced than the first, and so on for successive maxima. When r is large compared to the molecular diameter, the ordering effect of the central molecular disappears and the number of molecular centers in the shell is simply the product of the volume of the shell, $2\pi r^2 dr$, by the molecular density, N/v,

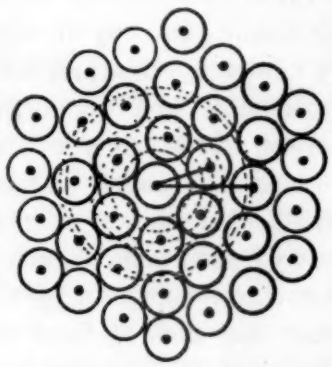

Fig. 2. Structure of a "perfect" liquid.

where N is Avogadro's number and v, the volume per mole. For small values of r this must be corrected by the factor, W, which is a function of r, as previously explained, whose form is represented in Fig. 3 and which expresses in a most useful way the structure of such a liquid. The form of this function was first determined by Menke for mercury and gallium, and more recently by Gingrich and coworkers for sodium and potassium. As might be expected, the form of the function, expressed in terms of molecular diameter, is essentially the same for these four substances; *cf.* Fig. 4. It varies slightly with the temperature, as one might expect, since thermal agitation and expansion tend to smooth it out to approach unity. My coworker, Dr. W. E. Morrell, was able to construct a model liquid with gelatin balls for molecules, which gave a distribution function of the same form, with a similar temperature dependence.

Having at hand such an expression to describe the structure of a perfect liquid it has been possible to solve an important problem, which is to connect the potential energy between pairs of molecules with the

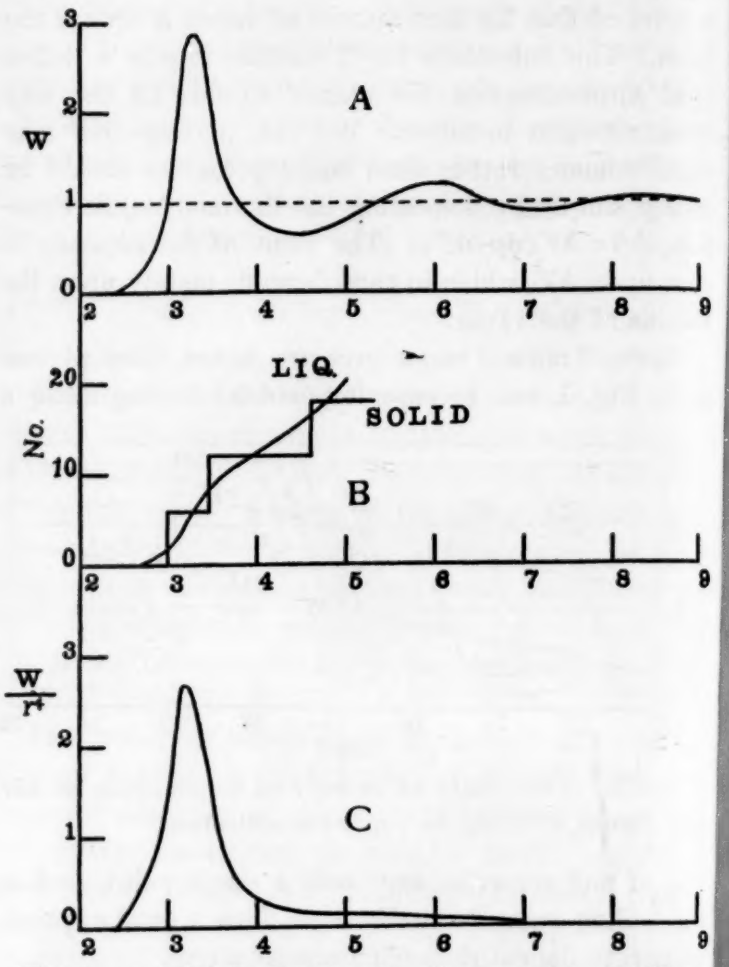

Fig. 3. A. Distribution function for mercury. B. Number of molecules around a central one at distance r. C. Potential function, area under which indicates small contribution by molecules beyond first layer to heat of vaporization.

potential energy of a mass of liquid E. This equation is

$$E = \frac{2\pi N^2}{\mathrm{v}} \int \varepsilon W r^2 dr. \qquad (1)$$

The important theoretical study by London of the forces between non-polar molecules which result from

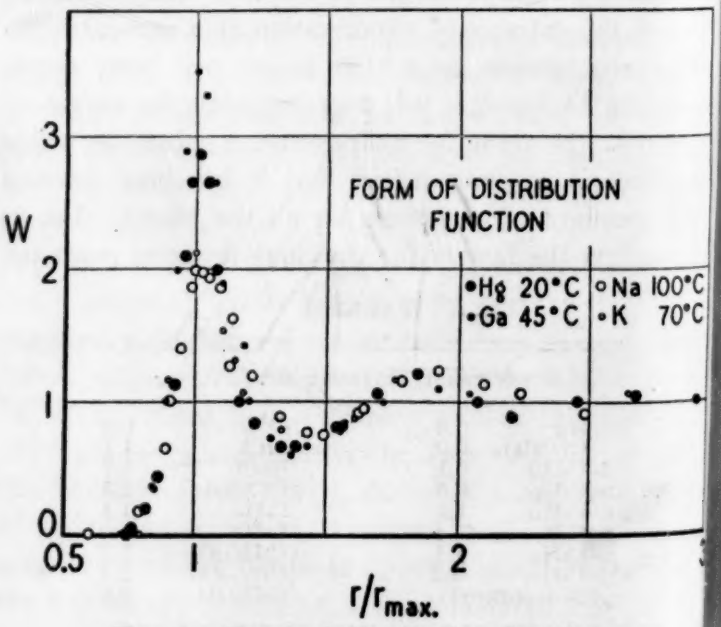

Fig. 4. Form of distribution function.

an interaction between their moving electrons shows that this potential varies inversely with sixth power of the distance, *i.e.*, $\varepsilon = -k/r^6$. If we substitute this expression for attractive potential in the preceding equation and neglect the repulsion we obtain the following expression, which throws light upon the energy of vaporization of a liquid.

$$\Delta E = \frac{-2\pi N^2 k}{v} \int \frac{W}{r^4} dr \qquad (2)$$

The value of the integral can be obtained by the aid of the curve in Fig. 3A and is represented by the area under the curve in Fig. 3C. (Curve B compares the structures of liquid and solid.) This curve shows what a small proportion of the energy of vaporization of a liquid is contributed by the molecules more than one diameter apart.

Again, the function plotted in Fig. 3A varies but slightly with temperature. The value of the integral determined graphically in the case of potassium drops off by some 5 per cent. in this range of temperature. We have known for some time that the energy of vaporization in a normal liquid is almost, but not quite, inversely proportional to its molal volume. We can see from equation (2) that it would be exactly proportional if the value of the integral were constant. As a matter of fact, I have shown recently that the drop of 5 per cent. in the value of the integral, together with the increase in molal volume for potassium when heated from 70° to 395°, accounts quite accurately for the decrease in the energy of vaporization of potassium in going from the lower to the higher temperature. Their ratio was calculated to be 1.154, while the measured values were in the ratio of 1.155. Moreover, I found that when benzene is expanded by the same amount, which in this case occurs between 0 and 72.5°, its energy of vaporization falls off in the same proportion as for potassium through the much longer temperature interval.

Turning now to solutions, let us begin again with the simplest conceivable cases, which will be solutions of spherical molecules of the same size and same molecular field strength. When such species are mixed an individual molecule has the same tendency to escape into a vapor phase as if it were surrounded entirely by its own kind. The number of molecules which so escape into a given vapor space will therefore be proportional to their percentage in the solution, and the solution obeys Raoult's law, the law of an ideal or perfect solution. The increase in free energy is $-RT \ln N_1$ and the increase in entropy is $R \ln N_1$, when one mole of component 1 is transferred from the pure liquid state to a large amount of solution in which the mole fraction is N_1.

If the molecules of the second species have not the same size but consist, say, of two normal paraffins of different length, we may expect them to be arranged in some approach to parallel array. An analysis of the number of arrangements possible in such a case shows it to be identical with the number in the preceding case, where molecules were spherical. In both cases, therefore, the degree of disorder is unchanged on mixing the two species, and hence the increase of entropy is the same, *i.e.*, $-R \ln N_1$ for each component. If the two species were as alike as two paraffins, we should expect little or no change in energy on mixing, *i.e.*, there should be no heat of mixing and therefore the free energy of mixing, which determines the vapor pressure, is dependent only on the entropy, hence the solution of long paraffin molecules, like the solution of spherical molecules, should obey Raoult's law, which is indeed the case, even for molecules of such different length as hexane and hexadecane.

Let us next consider spherical molecules of the same size but differing in strength of molecular field, as indicated by different energies of vaporization. In spite of the fact that the molecules with the larger attractive forces tend to squeeze out the molecules of the other component, we may choose temperatures sufficiently high so that thermal agitation may frequently overcome this tendency to segregation and give the same sort of random arrangement as exists in a pure liquid. For such a solution, the entropy of mixing will be the same as for an ideal solution; however, since the different attractive forces give rise to a heat or energy of mixing, the free energy change in forming the solution will not be ideal and the solution will not obey Raoult's law. Nevertheless, the fact that the entropy is ideal yields certain regularities in behavior which induced me to designate such solutions as "regular." If we can discover a satisfactory method for calculating the energy of mixing we can then get the free energy and hence vapor pressures and all other solubility relations. An extension of equation (2) to the case of a solution of two components of identical size, aided by the assumption, which is approximately true in the majority of cases, that the attractive constant between unlike molecules is the geometrical mean of the constants for the like species, gives the equation,

$$\bar{E}_1 - E_1^0 = [(\Delta E_1^0)^{1/2} - (\Delta E_2^0)^{1/2}]^2 N_2^2, \qquad (3)$$

for the energy of transferring a mole of component 1 from the pure state to a solution in which component 2 has a mole fraction, N_2. From this we can calculate the free energy and hence vapor pressures and solubilities.

When the molecules of the two species differ in size, the energy of mixing n_1 and n_2 moles of the components is

$$E = \frac{2\pi N^2}{v}\left[n_1^2 \int (11) + n_2^2 \int (22) + 2 n_1 n_2 \int (12) \right],$$

where $\int$ (11) is an abbreviation for $\varepsilon_{11}W_{11}r^2dr$, etc. We have to make certain approximations in order to derive from this an equation containing nothing but terms easily accessible to experiment. The resulting approximate equation for regular solutions in general is

$$RT\ ln\ (a_2/N_2 = V_2 \left(\frac{N_1V_1}{N_1V_1 + N_2V_2}\right)^2 \left[\left(\frac{\Delta E_1}{V_1}\right)^{1/2} \left(\frac{\Delta E_2}{V_2}\right)^{1/2}\right]^2 \quad (4)$$

This equation is extremely useful and makes it possible to calculate with a fair degree of accuracy solubilities of substances even in cases where the deviation from Raoult's law is enormous.

A number of the factors discussed above, as well as others, are illustrated strikingly by the solubilities of iodine plotted in Fig. 5. The ordinates are logarithms of the mole fraction of iodine in solution and abscissas

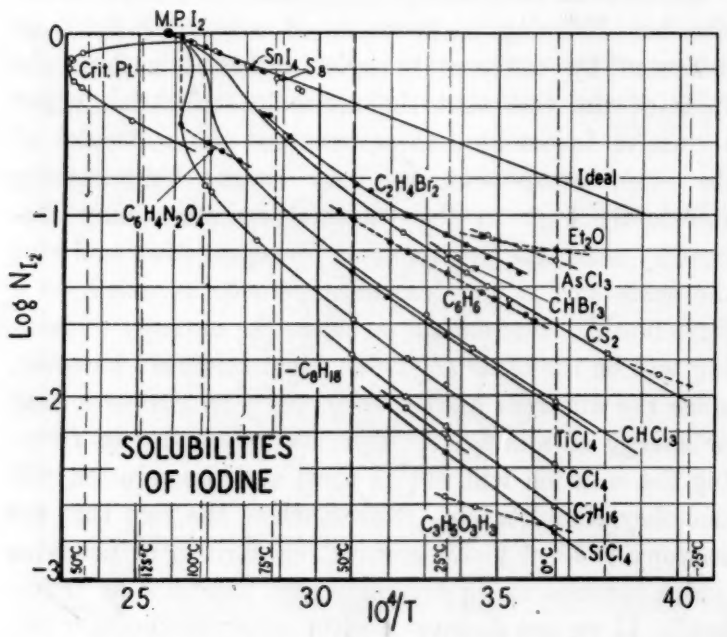

FIG. 5. Solubilities of iodine.

the reciprocal of the absolute temperature. The solid lines represent solutions whose color is violet, like iodine vapor; the broken lines represent red or brown solutions. The former obviously constitute a family of curves and indicate that these solutions are more or less regular; the latter are irregular. The ideal solubility is calculated by aid of the heat of fusion of iodine and difference between the specific heats of the solid and liquid.

Iodine has a high attractive field. Sulfur and stannic iodide do not differ from it much in this respect and are therefore able to mix with iodine in obedience to Raoult's law. As we descend the plot we encounter solvents of steadily diminishing internal pressures which are, therefore, progressively poorer solvents. The spacing of these curves corresponds rather closely to the difference between the internal pressure of iodine and that of the solvent in question. All we need to know in order to calculate the solubility of iodine in a solvent which gives a violet solution, where effects that we may call chemical are absent, is its energy of vaporization per cc. Of course, if we have one point on the solubility curve it is still better, for the general parallelism of the whole family of curves is quite evident.

An interesting extension of the curve for carbon tetrachloride was invited by the S-shape near the melting point, resulting from plotting the equation which fitted the observed points at lower temperatures. This S-shape indicates that there are two solutions of different composition in equilibrium with each other at the same temperature and that on raising the temperature iodine should melt to give a liquid incompletely miscible with carbon tetrachloride. It was estimated that these two liquid phases should have a critical solution temperature somewhat under 180° at a composition of about 71 mole per cent. of iodine. It was impossible to detect the presence of two phases by visual observation because of the opacity of iodine, consequently, a method was devised depending on the difference in density between the two liquid phases. The result was the determination of the liquid liquid-solubility curve shown in the upper left-hand portion of the figure, with a consolute temperature of 161° and a composition of 67 mole per cent. of iodine. This experiment constitutes a striking example of the value of the concept of regular solution. It is the more remarkable because in the region near the critical temperature there is undoubtedly an opposition between the mixing effect of thermal agitation and the segregating effect of different molecular attractions, which gives rise to clustering and departure from the randomness assumed in deriving the equation. Experiment shows, however, that this clustering is fortunately not sufficiently serious to introduce any serious error. This experimental conclusion has been recently brilliantly confirmed by Kirkwood by statistical mechanical analysis.

To recapitulate, there are but very few perfect liquids. There are many normal or approximately perfect liquids; still more which are abnormal due to pronounced lack of symmetry either of shape or of electrostatic field, and there are a number which are highly abnormal due to the presence of hydrogen bonds or other chemical bonds.

Similarly, there are but very few solutions which are ideal or perfect with any high degree of accuracy, at least through any considerable range of composition. A much larger number are approximately regular, *i.e.*, they show ideal entropy of mixing, although their free energy of mixing is not ideal. They may be regarded therefore as approaching a considerably lower, more easily attainable ideal.

Let us now turn our attention to solutions which show marked departure from regularity. Solutions of iodine in ethylene bromide, whose solubility curve is

shown in Fig. 5, present an interesting example. The slope of the curve does not correspond to the family of curves for violet solutions, in spite of the fact that these solutions alone among all the divergent solutions are violet in color, indicating absence of any type of solvation. The polar character of ethylene bromide does not suffice to explain this anomaly, for chloroform, which has almost as large a dipole moment, gives regular solutions. The explanation seems rather to lie in a change in the structure and hence in the entropy of the ethylene bromide caused by changing temperature and iodine content. The dipole moments of ethylene chloride, and doubtless also of ethylene bromide, are highly dependent upon the particular inert solvent used in measuring them. It is evident that the rotation possible about the carbon to carbon bond introduces possibilities of structural change in the liquid which we may, at least at present, regard as responsible for the regular entropy of the solutions of iodine in this solvent.

The dotted curves in Fig. 5 all correspond to solutions which are brown in color and whose absorption bands shift with temperature, indicating changes in structure attending changes in degrees of solvation and, in certain cases also, of degree of association of the solvent.

An interesting departure from regularity has been recently reported by Scatchard and Wood for a solution that might have been expected to behave quite regularly, namely, benzene and cyclohexane. It was shown, however, that the heat and free energy of mixing are different, indicating an increase of entropy upon forming the solution. If we turn back to the evidence presented in Table I that both benzene and cyclohexane possess some structure, we can see that a decrease in the amount of structure when the two components are mixed would account for the increase in entropy. Since benzene rings are flat while cyclohexane rings are puckered, it is easy to see how the two slightly different kinds of structure would tend to interfere with each other and give rise to an increase in the general disorder.

This point of view has suggested itself so recently that not many cases have been examined to test its general validity. However, the cases so far examined give great promise that the theory will prove useful.

The large deviations, not only from ideal but also from regular behavior that accompany chemical combination are highly specific, and often strain our skill in predicting the strength of chemical union. We are assisted, however, by a large body of knowledge regarding the relative strengths of acids and bases and can safely predict that the stronger the union between a basic and acidic substance the more strongly will their solution deviate from regular behavior in the direction of increased solubility.

Again, there are only a few types of strong hydrogen bonds, since strong union through hydrogen occurs only with nitrogen, oxygen and fluorine. There is considerable hope that we may be able to set up approximate values of the strength of the bond between the like and unlike combinations of these three elements, which values will be subject to modification depending upon the rest of the molecule. We may hope that in many cases this modification may prove to be small, *e.g.*, the strength of the bond in alcohol can not be changed very much by the size of the alkyl group. The amino acids and proteins, despite their almost infinite variety, contain but a few types of hydrogen bonds, and we may hope to arrive at a good deal of understanding of their solubility relations by the aid of this simplification.

I should like to conclude by emphasizing a particular liquid structure which has a greater practical importance for us than any other, namely, the structure of water. We are still under the spell of an over-simplified theory of solution, which regarded the solvent mainly as affording space in which the solute could masquerade as a gas. It is true that we have now ascribed to this space a dielectric constant, but most papers dealing with aqueous solutions, particularly those of electrolytes, ascribe no further physical properties to the water than this. Any deviation from the laws of perfect solution, which for such substances can at best be true only at high dilution, are often "explained" by subtracting some of the water from its role as solvent and calling it water of hydration. What this can mean, physically, is often obscure, for all the water molecules are linked together by hydrogen bonds except in so far as they are momentarily disturbed by thermal agitation and, if the solute is chemically bound to some of the water and this is in turn chemically bound to water molecules farther removed, I do not see how one can draw a definite boundary between the water which is acting as solvent and that which is acting as water of hydration.

It seems to me that if we were not so influenced by the accident of the particular historical approach to the theory of solution upon which most of us have been brought up, we would not find it so difficult to approach an aqueous solution from the opposite point of view, which is to think of water as a chemical substance whose role in the solution is just as dignified as that of the solute and which is, moreover, a substance having a high degree of structure. We may then inquire what might be expected to happen if we would introduce into this structure solutes of different types, including, first, ions, small and large, with single or multiple charges; second, molecules with dipoles or, third, molecules which themselves can participate in the formation of hydrogen bonds. Latimer, in a series of important studies, has already shown that the

entropy of solution of ions can be explained on the basis of alterations in the structure of the water. I venture to assert that the fruitfulness of such an approach is far from being exhausted.

For a long while we were satisfied with the classification of liquids into normal liquids, polar liquids and fused salt solutions. It became evident, however, that the mere fact of dipole moment was inadequate to account for solubility relations. We find, on the one hand, that iodine dissolves in chloroform, which is polar, and in carbon tetrachloride, which is non-polar, to give approximately regular solutions in both cases. Again, naphthalene, with zero dipole moment, dissolves in nitrobenzene, with a very large moment, to give an almost perfect solution. The polar character of the nitrobenzene causes little or no tendency for it to associate with itself rather than with the non-polar solute. We find, moreover, that although solubility in water has usually been regarded as proportional merely to the polar character of the substance in question, dipole moment alone is actually a very misleading guide. A striking illustration of this is given in Table II.

TABLE II
SOLUBILITY OF LIQUIDS IN WATER, 20°

	Per cent.	$\mu \times 10^{18}$
Benzene	0.06	0.
Nitrobenzene	0.19	4.19
Aniline	3.49	1.51
Phenol	8.2	1.70
Ethyl iodide	0.40	1.66
Ethyl alcohol	∞	1.70
Propyl chloride	0.27	2.0
Propyl iodide	0.11	1.6
Propyl alcohol	∞	1.7
Water	...	1.85

We see that the solubilities of benzene and its three substitution products in water do not at all follow their dipole moments. These solubilities do, however, accord with the amount of hydrogen bond formation that may be expected in solutions of water with aniline and phenol, respectively. A similar difference exists between ethyl and propyl halides and alcohols. It is the ability of the hydroxyl of the alcohol or the phenol or the amino group in aniline to enter more or less into the structure of the water which accounts for their solubility. The structure of ice is an open, continuous structure, like that of trydimite, and contains no permanent individual molecules. The structure of water at lower temperature is the same, more or less broken down by thermal agitation. Hydroxyl containing substances such as the alcohols are similar except for the fact that the substituted groups diminish the number of hydrogen bonds. The profound difference between liquids containing ordinary dipoles, such as acetone and chlorobenzene and liquids containing hydroxyl, such as the alcohols, is illustrated in Fig. 6 showing the alteration in molar polarization when mixed with varying amounts of an inert solvent. The carboxyl group of organic acids, however, allows two molecules of the acid to form a closed ring so that the polymerization is limited to a double molecule. This molecule may, except in extreme dilutions, behave as a constituent of regular solutions.

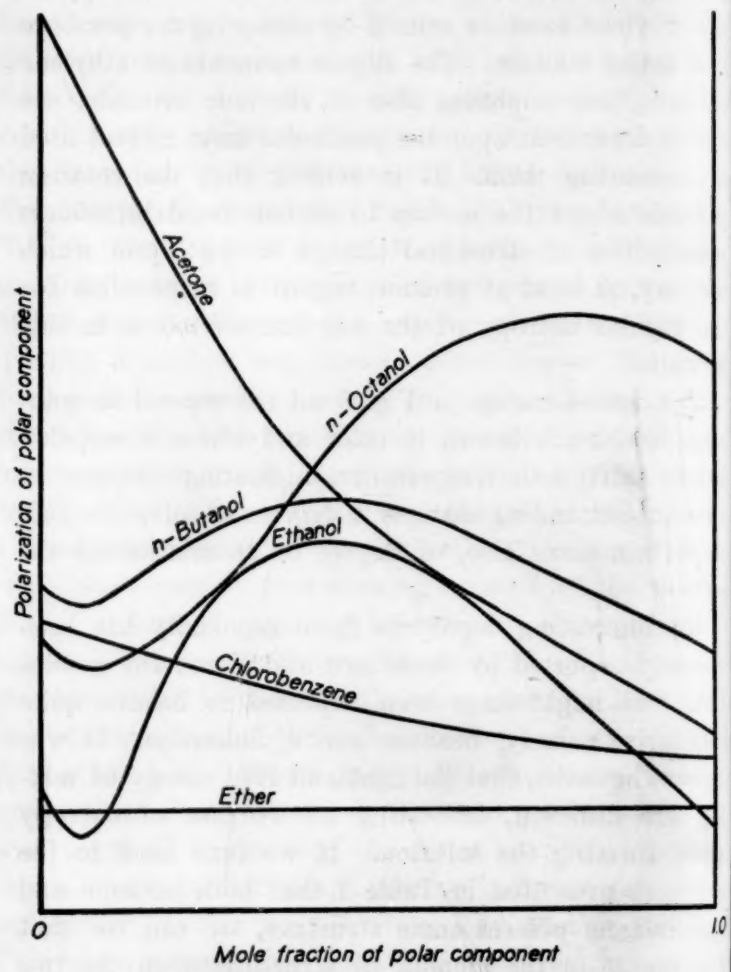

FIG. 6. Variation of molar polarization with concentration.

OBITUARY

DAVID TODD

WITH the passing of David Todd, on June 1 in Lynchburg, Virginia, at the age of 84, Amherst College lost another of the distinguished group of professors who added much to its prestige around the beginning of the century. The names of Tyler, Emerson, Olds, Loomis, Todd and the others were well known and respected both within and without the walls; and the last named of these was likely to receive the vote of the graduating class as the best known of all.

David Todd was born on March 19, 1855, in Lake Ridge, New York, the son of Sereno Edwards and

Rhoda Peck Todd, and a descendant of Johnathan Edwards. He enrolled in Columbia College, New York, in 1870, and entered Amherst College in 1873, where he received the A.B. degree in 1875, with membership in Phi Beta Kappa. He received the honorary Ph.D. degree from Washington and Jefferson College in 1888. After an absence of six years, in which he served under Simon Newcomb at the U. S. Naval Observatory in Washington, he returned to Amherst, in 1881, to take the new chair of astronomy. He was appointed professor of astronomy in 1892; he also served as secretary of the faculty of the college from 1891 to 1909, and was professor of astronomy and higher mathematics in Smith College from 1882 to 1887. He became professor emeritus in 1920.

More than a hundred technical and popular articles were contributed by Dr. Todd to various periodicals; they relate to solar eclipse problems, the solar parallax as derived from the transit of Venus, the orbits of the four bright satellites of Jupiter, the search for a trans-neptunian planet and other subjects. He contributed to Webster's Dictionary and to the Encyclopaedia Britannica. His best-known book is the "New Astronomy," first published in 1897, which has gone into many editions and is translated into Hungarian, Turkish and Chinese. He was a fellow of the American Association for the Advancement of Science, a member of the American Astronomical Society, the Washington Philosophical Society, the Astronomische Gesellschaft and honorary fellow of the Sociedad Geografica de Lima, Peru. He designed and supervised the construction of the Observatory of Smith College, and was instrumental in procuring funds to build the Amherst College Observatory, completed under his supervision in 1905, and to equip it with the excellent 18-inch refracting telescope by the Clarks.

Dr. Todd's interest in solar eclipses led him to many parts of the world. He was in charge of the National Academy of Sciences expedition to Japan in 1887, the U. S. Scientific Expedition to West Africa in 1889, and the Amherst expeditions to Japan in 1896, to Tripoli in 1900, to the Dutch East Indies in 1901, to Tripoli again in 1905 and to Russia in 1914. He invented an automatic device for photographing eclipses, and his misfortune with clouds on some of these occasions led to the keeping of meteorological records at selected stations for several years in advance of the eclipse. In addition, he was invited to direct the observations of the transit of Venus of 1882 at the Lick Observatory, then under construction on Mount Hamilton, California, and he cooperated with the astronomers of the Lowell Observatory in an expedition to Chile to photograph the planet Mars around the favorable opposition of 1907.

Dr. Todd's hobby was aviation, beginning as early as the 1880's. He took part in a number of balloon flights. He was founder member of the Aero Club of America, a member of the Board of the National Advisory Association of Aeronautics and of the Board of Governors of the Aerial League of America. In 1908, he founded at Amherst one of the first college aviation clubs, the Amherst Aero Club, the forerunner of the present Amherst College Flying Club.

Dr. Todd married Mabel Loomis, in 1879, who died in 1932. He is survived by his daughter, Mrs. W. V. Bingham.

ROBERT H. BAKER

HARVARD OBSERVATORY

RECENT DEATHS

DR. CHARLES ADDISON ELLIOTT, professor of medicine at the Medical School of Northwestern University, chief of the medical service of Passavant Hospital, Chicago, died on June 26 at the age of sixty-six years.

DR. HARRY VICTOR ATKINSON, professor of physiology and pharmacology at the School of the Medical Sciences of the University of South Dakota, died suddenly on May 7 at the age of fifty-two years.

GUY PINNER, chief engineer of the American Cyanamid Company, died on June 26 at the age of fifty-one years.

EMMA SAREPTA YULE, pioneer in educational work in Juneau, Alaska, and in the Philippines and for fifteen years editor of the *Philippine Agriculturist*, died in Los Angeles on April 16.

PROFESSOR HARRY HUNTINGTON BARNUM, head of the department of mathematics at Robert College, Istanbul, Turkey, has died at the age of sixty-one years. He had been a member of the college faculty for thirty-nine years.

SCIENTIFIC EVENTS

EXCHANGE OF VISITS BETWEEN THE ROYAL SOCIETY AND THE KAISER WILHELM GESELLSCHAFT

IN the autumn of 1938, following a suggestion of the president of the Kaiser Wilhelm Gesellschaft, arrangements were made by the president of the Royal Society of London, Sir William Bragg, and representatives of the Kaiser Wilhelm Gesellschaft, for an exchange of visits between these two bodies. The Kaiser Wilhelm Gesellschaft, founded in 1911 at the suggestion of the Kaiser Wilhelm II, has at its aim the encouragement of the natural and human sciences, primarily by establishing and maintaining research institutes for natural science in Germany.

This exchange of visits was welcomed by the Royal Society, which, since its foundation in 1662, has always sought to maintain, irrespective of race or politics, the liveliest interest in the work of men of science throughout the world. Consequently, arrangements were made for two fellows of the society, Professor F. G. Donnan, emeritus professor of chemistry in the University of London, and Professor A. J. Clark, professor of materia medica in the University of Edinburgh, to visit Germany in March; at the express wish of the Kaiser Wilhelm Gesellschaft for a lecture on a non-scientific subject, Professor Dover Wilson, the eminent Shakespearean scholar, was invited by the Royal Society to visit Berlin to lecture. The visits, which took place in March and April, were highly successful. The visitors were most hospitably entertained by their German colleagues and were afforded facilities for visiting laboratories and research institutes.

The Royal Society is entertaining during this month four German men of science. They are Freiherr von Verschuer, of the University of Frankfort-on-Main; Professor R. Kuhn, of the Kaiser Wilhelm Institut für Medizinische Forschung, Heidelberg; Professor F. Wever, of the Kaiser Wilhelm Institut für Eisensforschung Forschung, Düsseldorf, and Professor Otto Hahn, of the Kaiser Wilhelm Institut für Chemie, Berlin-Dahlem. Freiherr von Verschuer and Professor Kuhn delivered lectures before the Royal Society on June 8 and 9, respectively; Professor Wever spoke on June 22 on metallurgical research, and Professor Hahn spoke at the Royal Institution on June 23 on the fission of uranium nuclei by neutrons.—*Nature.*

SURVEY OF THE GEOLOGY OF THE CENTRAL ANDES IN PERU

DR. J. V. HARRISON, university demonstrator and lecturer in the department of geology at the University of Oxford, who is leading an expedition to Peru, is reported by a correspondent of the London *Times* to have sailed from Liverpool on June 17, to study and map the geology of a part of the Central Andes of Peru in the region between Canta, Huaauco and Huancayo. Dr. Harrison, who was in the same part of Peru in 1925, is accompanied by J. D. Weir, of University College, London, and Saskatoon University, who is a Rhodes scholar and a Burdett-Coutts scholar and who is working in the department of geology; C. H. Kearny, of the Queen's College, who is a Rhodes scholar from Princeton, and M. H. Donald, of Mealsgate, Cumberland, who has previously collected for the British Museum.

The expedition will collect fossils and specimens of rocks from the region for the British Museum (Natural History). Its plans have been approved by the Royal Geographical Society. The area to be mapped is part of an equilateral triangle, the apices of which are Tarma, Cerro de Pasco and Canta, with the center of the triangle roughly 80 miles northeast of Lima.

How much will be achieved depends entirely upon the weather, which in August and September can not be relied on. The altitudes range from 15,000 feet to 18,000 feet, and the region is subject to violent storms during the break-up of the settled July (winter) weather. Much of the time will be spent under canvas, and the expedition will rely on mule transport, with native muleteers.

Mr. Weir was with survey parties of the Canadian Geological Survey in two successive summers before he went to Oxford, and he has this year been awarded a third part of the Daniel Pidgeon Fund by the Geological Society. The first recipient of this award, in 1908, was the present professor of geology at Oxford, Professor James A. Douglas, who himself did much of his early field work in Peru and is an authority on the geology of that country.

Mr. Kearny, who collected archeological material in northwestern Mexico for a year before going to Oxford, will join the party at Lima. The expedition will return in October.

THE MAGELLANIC EXPEDITION OF THE FIELD MUSEUM

THE "Magellanic Expedition" of Field Museum of Natural History, sponsored by Stanley Field, president of the museum, which will largely retrace in the farthest reaches of South America the steps of the early Spanish explorer for which it is named, planned to sail from New York for Lima, Peru, during the first week in July. Those sailing include Karl P. Schmidt, curator of amphibians and reptiles, his son, John Schmidt, field assistant, and Colin C. Sanborn, curator of mammals. They will be joined, probably in September, by Dr. Wilfred H. Osgood, chief of the department of zoology.

The expedition will attempt to complete the fragmentary knowledge of the fauna of the southern half of South America. All classes of animals will be sought—mammals, birds, reptiles, fishes, insects, marine invertebrates, etc. It is planned to explore the shores of the Straits of Magellan and the Island of Tierra del Fuego to the extreme southern tip of the continent.

Upon arrival in Lima, Mr. Schmidt and his companions will cross southern Peru by rail to Arequipa and Lake Titicaca, where collecting will begin. Crossing the lake by steamer, collections will be made in Bolivia. Further penetration into the interior of South America will be made variously by airplane, rail, boat, pack animals and afoot. After the arrival of Dr. Osgood the expedition will proceed through Chile down to the southernmost tip of the continent. It is in the region of the Straits of Magellan and Tierra

del Fuego that it is expected the most important research will be conducted.

Dr. Osgood has made the following statement:

This region has not been scientifically explored by zoologists for more than one hundred years. In 1834, Darwin collected in this region, during the famous cruise of the *Beagle*. Since that time it has been neglected. Although Darwin made excellent collections of the fauna, which are still preserved in the British Museum, there are many gaps which remain to be filled in available knowledge of the natural history of the region. The Darwin collections are not satisfactory from to-day's standards because, naturally, facilities and techniques for the collecting and preservation of specimens had not been developed in his time to the point since achieved. On the Field Museum expedition it is expected that data will be obtained which will make possible the completion and revision of present knowledge based on the Darwin collections. It may be confidently expected further that we shall obtain examples of many species of animals still unknown or hitherto unrepresented in any collections.

Although the expedition will be concerned primarily with assembling specimens for research collections of the museum, specimens will be sought also for addition to the public exhibits and for one or two habitat groups showing animals in scenes reproducing their natural environments.

A FISHERIES BIOLOGICAL LABORATORY ON THE GULF COAST

THE need has long been felt for an adequate marine biological laboratory on the Gulf Coast. To achieve this end the Bureau of Fisheries took possession of the abandoned Pensacola, Florida, Quarantine Station in September, 1937. Since that time, with the aid of grants from the Public Works and Works Progress Administrations, much has been accomplished toward enlarging existing facilities and adapting them to the needs of biological research. While the program of construction is not yet completed it is sufficiently far advanced to merit a statement of the facilities which will soon be available for biological research related to fisheries.

The station is located on a ballast rock island of 14 acres about seven miles from Pensacola. The island is about a half mile from the highway, but construction of a bridge and road to the station is under way. The location is one of the most favorable on the Gulf Coast, for it is relatively central and the marine fauna and flora are characteristic of the coast as a whole. The island is in Santa Rosa Sound, protected from storm damage by the 45-mile long Santa Rosa Island. The water of the sound is almost always clear and of a salinity generally ranging from 20 to 25 parts per 1,000 save in times of extreme precipitation, when it may fall to about 15 p.p. 1,000. Within a few miles are various bays, bayous and rivers offering any type of marine habitat. The gulf beach, where the water is always remarkably clear, is only a mile away. In the immediate vicinity an extensive fishery is carried on for red snapper, grouper, mackerel, mullet, flounder, pompano, shrimp, oysters and crabs. Within a mile of the laboratory one may find any type of bottom from firm sand to soft mud. The island itself, consisting of ballast rock, attracts a wide variety of marine life.

The laboratory building has been considerably enlarged and consists of the following rooms: a general research room 23 feet wide by 45 feet long, five private research rooms, a chemical research room, a dark room for experimental and photographic purposes, a stock room, an office, a large library and reading room, and a specimen room or museum 34 feet wide by 60 feet long. Running salt water will be provided wherever required. On the grounds are two concrete experimental tanks 15 by 30 by 5 feet deep, and two 10 by 20 feet by 5 deep. These will be supplied with running seawater.

Accommodations for a limited number of investigators are provided in a dormitory building which consists of five 2-bed rooms, a bath, a kitchen and a large combination dining and living room. In addition there is a large room, which will accommodate four beds, and a separate bath. Also on the island are a work shop, boat house and residence buildings for the accommodation of the regular staff. Two motor boats and several skiffs with outboard motors are available.

Those interested in obtaining further information may address the director, Dr. A. E. Hopkins, Bureau of Fisheries, P. O. Box 1456, Pensacola, Fla.

AWARDS OF THE AMERICAN GEOGRAPHICAL SOCIETY

THE American Geographical Society of New York has announced the award of the Cullum Geographical Medal for 1938 to Emmanuel de Martonne, professor of geography at the University of Paris. The Charles P. Daly Medal for 1939 has been awarded to Herbert John Fleure, professor of geography at the University of Manchester, and the David Livingstone Centenary Medal for 1939 has been awarded to John R. Rymill in recognition of his scientific achievement and exploration in the southern hemisphere. Presentations of the medals will be made later in the year.

Professor de Martonne's special field is physical geography, a subject on which he has written many volumes, including "Europe Centrale" and the standard manual "Traité de géographie physique." He is president of the International Geographical Union and is one of the editors of the *Annales de Géographie*. In 1916–17 he was visiting professor at Columbia Univer-

sity. Among previous recipients of the Cullum Medal have been Robert E. Peary, Robert F. Scott, Sir Ernest H. Shackleton and Albert I, Prince of Monaco.

Professor Herbert John Fleure is known for his work on human geography. He is honorary secretary of the British Geographical Association and honorary editor of the magazine *Geography,* published by the association, and has taken an active part in the Regional Survey Movement in Great Britain. He is the author of several books and a number of articles, some of which have appeared in *The Geographical Review,* and is the joint author of "The Corridors of Time." Among those who have received the Charles P. Daly Medal in the past have been Roald Amundsen, Vilhjalmur Stefansson, Sir Francis Younghusband, Robert A. Bartlett and Roy Chapman Andrews.

John R. Rymill, to whom the David Livingstone Centenary Medal has been awarded, served as surveyor on two British Arctic air route expeditions led by H. J. Watkins. When, in 1932, on the second of these expeditions, Watkins died, Mr. Rymill succeeded him as leader. In 1935 he organized the British Graham Land expedition, which from January of that year to March, 1937, carried on, under his leadership, highly important, accurate, detailed survey work in Graham Land on the Antarctic Continent. The David Livingstone Centenary Medal has been awarded in the past to Theodore Roosevelt, Richard Evelyn Byrd, Hjalmar Riiser-Larsen and Lincoln Ellsworth.

Honorary membership in the society has been awarded to Sir Wilfred Grenfell for his contributions to geographical knowledge concerning the Labrador Peninsula; Henri Baulig, geomorphologist and professor of geography at the University of Strasbourg, and Giotto Dainelli, professor of geology and physical geography at the University of Florence.

Corresponding memberships have been awarded to: Ernst Antevs, research associate of the Carnegie Institution of Washington; Ludwig Leonhard Mecking, professor of geography at the University of Münster; William E. Rudolph, a civil engineer who has carried out extensive explorations in South America; Paul Gerhard Schott, retired section chief of the Deutsche Seewarte and honorary professor at the University of Hamburg, and Laurence Dudley Stamp, a reader in economic geography at the University of London and director of the Land Utilization Survey of Great Britain.

SCIENTIFIC NOTES AND NEWS

THE University of St. Andrews will confer the honorary degree of doctor of laws at a graduation ceremonial to be held in Dundee during the visit of the British Association for the Advancement of Science to that city, on the following: William Boyd; Broughty Ferry; Frederick Tom Brooks, professor of botany at the University of Cambridge; William Graham Campbell, lecturer in orthodontics at the Dental School of the university; Charles Galton Darwin, director of the National Physical Laboratory; Alexander McKenzie, professor of chemistry emeritus at University College, Dundee; Sir Albert Charles Seward, until 1936 professor of botany at the University of Cambridge, president of the British Association; Professor Richard Vynne Southwell, professor of engineering science at the University of Oxford, and Sir Aurel Stein.

THE degree of doctor of science was conferred by the University of Pittsburgh at the commencement exercises on June 14 on Dr. Davenport Hooker, professor and head of the department of anatomy in the School of Medicine.

THE honorary degree of doctor of science was conferred by the Ohio Wesleyan University at its commencement on June 12 on Dr. C. E. Ferree, director of the research laboratory of physiological optics of the Johns Hopkins University.

THE honorary degree of doctor of science was conferred upon Admiral Leo Otis Colbert, director of the U. S. Coast and Geodetic Survey, by Tufts College, Massachusetts, at its eighty-third commencement exercises, by President Leonard Carmichael. The citation read: "The world has never needed maps more than it does to-day. Leo Otis Colbert, gifted investigator and cartographer-in-chief of our coasts, I confer upon you the degree of Doctor of Science."

THE annual award of the American Pharmaceutical Manufacturers' Association was presented to Dr. Nathan B. Eddy and Dr. Lyndon F. Small, of the U. S. Public Health Service, at the recent annual meeting, in recognition of the "fundamental and outstanding studies of the chemistry, pharmacology and therapeutics of morphine derivatives for the alleviation of human suffering."

FOR his paper presented at the 1938 annual meeting of the American Society for Testing Materials on "Drying Shrinkage of Concrete as Affected by Many Factors," R. W. Carlson, associate professor of civil engineering at Massachusetts Institute of Technology, has been awarded the Charles B. Dudley Medal of the society. This medal, which commemorates the name of the first president of the society, is awarded "to the author of the paper which is of outstanding merit constituting an original contribution on research." The presentation was made at the annual meeting on June 28.

THE Andrew Carnegie Gold Medals of the British Iron and Steel Institute for 1938 have been awarded to Dr. James White, of Glasgow, for his paper on "Equilibrium at High Temperatures in Systems Containing Iron Oxides," and to Dr. W. Ruff, of Wetzlar-Lahn, Germany, for his paper on "The Running Quality of Liquid Malleable Iron and Steel," published in 1936.

A PORTRAIT of Dr. Edward Lee Thorndike, professor of educational psychology and director of the Division of Psychology of the Institute of Educational Research at Teachers College, Columbia University, has been presented to Wesleyan University, from which he graduated in 1895. The portrait, which was painted by Howard L. Hildebrandt, was placed on public view on June 18 in the Honors College of the university.

VISCOUNT NUFFIELD and John Davison Rockefeller have been elected fellows of the Royal Society in accordance with the terms of Statute 12, which provides for the election of persons who, in the opinion of the council, "either have rendered conspicuous service to the cause of science, or are such that their election would be of signal service to the society."

DR. ALBRECHT PENCK, professor of geography at Berlin, has been elected a foreign member of the Vienna Academy of Sciences. The honorary doctorate of the University of Berlin has also been conferred on Dr. Penck.

M. LÉON BINET, professor of physiology in the Paris Faculty of Medicine, has been elected a member of the Académie de Médecine in the section of biological sciences, in succession to the late Dr. Antoine Béclère.

DR. HANS SPEMANN, professor of embryology at Freiburg in Breslau, celebrated his seventieth birthday on June 27; Dr. Walther Nernst, professor of physics at Berlin, celebrated his seventy-fifth birthday on June 25, and Dr. Max Planck, professor of physics at Berlin, celebrated the sixtieth anniversary of his doctorate on June 28.

DR. G. DONALD HUDSON has been appointed professor of geography at Northwestern University. For the past five years he has been with the Tennessee Valley Authority, first as chief of the Section of Geography and later of the Land Planning Division.

DR. MALCOLM BRUS KILDALE, of Salt Lake City, Utah, has been appointed successor to Cyrus Fisher Tolman, who retired from the chair of economic geology at Stanford University in 1938.

DR. LEO HESS, privat-docent in the department of internal medicine at the University of Vienna, arrived on June 27 in Waltham, Mass., to take up his work in the School of Medicine of Middlesex University.

DR. OWEN HERBERT WILLIAMS, lecturer in clinical surgery, honorary surgeon to the Royal Liverpool United Hospital and honorary surgeon to the Liverpool Radium Institute, has been appointed professor of surgery at the University of Liverpool, in succession to Professor R. E. Kelly, who is retiring on reaching the age limit.

DR. J. F. MCCLENDON has resigned as professor of physiological chemistry at the Medical School of the University of Minnesota, in order to accept the research professorship of physiology at the Hahnemann Medical College, Philadelphia.

DR. WINIFRED GOLDRING, assistant state paleontologist of the New York State Museum at Albany, has been promoted to the position of state paleontologist to succeed Dr. Rudolf Ruedemann, who retired on November 1, 1937. Dr. Goldring has had a provisional appointment since August 1, 1938.

DR. WILLARD M. HOEHN, research associate in biochemistry, Mayo Foundation and Mayo Clinic, has resigned to become endocrinological chemist at George A. Breon and Company, Inc., Research Laboratories, Kansas City, Mo.

DR. WILLARD C. RAPPLEYE, dean of the College of Physicians and Surgeons of Columbia University, was elected president of an advisory council established at a meeting held on June 24 at Chicago, by representatives of the Association of American Medical Colleges, the American Hospital Association, the Catholic Hospital Association, the Federation of State Medical Boards of the U. S. A., the Advisory Board for Medical Specialties, the National Board of Medical Examiners, the American College of Physicians, the American College of Surgeons, the Association of American Universities, the American Association for the Advancement of Science and the American Public Health Association. The purpose of the council is to correlate the efforts of universities, hospitals, licensing bodies, public health associations and boards of specialists.

Nature reports that the British Medical Research Council has appointed the following committees to advise and assist in promoting investigations into problems of preventive medicine: Sir W. Wilson Jameson, dean of the London School of Hygiene and Tropical Medicine, *chairman*, J. H. Brincker, J. Fenton, J. Ferguson, W. M. Frazer, L. H. R. Harries, A. Bradford Hill, W. D. Hood, J. R. Hutchinson, R. A. McCance, A. S. M. MacGregor, R. H. Parry, Professor R. M. F. Picken, W. M. Scott, J. C. Spence, Professor W. W. C. Topley, D. K. M. Chalmers, of the National Institute for Medical Research, *secretary*.

PROFESSOR ERNEST B. BABCOCK, head of the Division of Genetics of the College of Agriculture of the

University of California, has been invited to serve as a vice-president of the seventh International Botanical Congress, which will be held in Stockholm in July, 1940.

THE John and Mary Markle Foundation of New York recently made a grant of $3,000 for studies of liver poisoning in the department of chemistry at the Medical College of Virginia. This project will be under the direction of Dr. J. C. Forbes, associate professor of biochemistry at the college. The Dazian Foundation for Medical Research has also made a grant of $700 to the college for research in preventive medicine.

THE Committee on Scientific Research of the American Medical Association has made a grant to Dr. Max Schnitker, junior attending surgeon of the neurosurgical service of Toledo Hospital, Ohio, for investigations on the Berger Rhythm to be carried out in the department for medical research. A grant has been made to the department of surgery of the University of Chicago for aid in continuing work on the problem of ascertaining the mechanism of the recovery of blood pressure on completely sympathectomized dogs.

PROFESSOR G. D. HALE CARPENTER, who succeeded Sir Edward Boulton as head of the Hope department of zoology (entomology) of the University Museum, Oxford, has accepted an invitation from the chairman of the National Research Council in Washington, D. C., to attend the Pacific Science Congress in California, which will be held from July 24 to August 12. In California, he will be met by E. P. Mumford, an official member of the congress, now at Columbia University, on leave of absence from Oxford.

STANLEY D. WILSON, dean of the College of Natural Sciences and professor of organic chemistry at Yenching University, Peiping, China, is returning to the United States for a year's furlough beginning this July.

THE officers, executive committee and members of the Division of Geology and Geography, National Research Council, for the year beginning July 1, 1939, are as follows: *Chairman,* Chester R. Longwell; *Vice-chairman,* Preston E. James; *Executive Committee,* Chester R. Longwell, Preston E. James, Edson S. Bastin, Stephen R. Capps, Charles C. Colby, George Tunell; *Representatives of Societies,* Stephen R. Capps and John L. Rich, Geological Society of America; George Tunell, Mineralogical Society of America; Charles E. Resser, Paleontological Society; Preston E. James and C. Warren Thornthwaite, Association of American Geographers; Charles B. Hitchcock, American Geographical Society; Edson S. Bastin, Society of Economic Geologists; Robert B. Sosman, American Ceramic Society; F. H. Lahee, American Association of Petroleum Geologists; *Members at Large,* Norman L. Bowen, Charles C. Colby and Chester R. Longwell.

FOR some time past it has been occasionally impossible to accommodate investigators from other universities at the Biological Laboratory of the Atkins Institution, Soledad, Cienfuegos, Cuba. This difficulty has usually arisen from the fact that a good many visitors from Cambridge, both zoological and botanical, use Harvard House at Soledad during the summer months. This situation now is entirely changed. A new building has been erected with comfortable sleeping accommodations for sixteen persons so that there should be no question whatever, in the future, of overcrowding. Harvard University, therefore, will welcome inquiries concerning the facilities which are offered at the Cuban Station, where board and lodging are provided at $2.50 a day. Inquiries concerning the station may be addressed to Thomas Barbour, Custodian, Museum of Comparative Zoology, Cambridge, Massachusetts.

THE department of geology of the University of Kansas plans an enlarged program for the coming year. New curricula leading to the degree of B.S. in geology are to be introduced, with provision for options in general, petroleum, mining or geophysical work. On the graduate level, new courses in stratigraphy, ground water geology and geologic interpretation of aerial photographs will be offered by Dr. R. C. Moore, Dr. K. K. Landes and Dr. H. T. U. Smith, respectively. Dr. Robert M. Dreyer will be added to the instructional staff, and Dr. Landes will begin serving as chairman of the department, succeeding Dr. Moore, who has withdrawn in order to devote more time to the expanded program of the State Geological Survey.

THAT the leaders of science in Czecho-Slovakia have made every endeavor to continue scientific investigations during the past fateful year is indicated, according to *Nature,* by the fifteenth annual report of their National Research Council. At the annual general meeting in March, Professor B. Němec referred to the interruption of scientific work occasioned by the country's loss of territory and institutions. Research activities were therefore upon a restricted basis, though, he emphasized, it is necessary for a small nation to maintain its cultural activities at the highest possible level. He urged that renewed efforts be made to utilize all the country's remaining scientific institutions and resources for the continuance of all programs of research. Dr. Ulrich, secretary of the council, stated that donations were received from industries, corporations and private individuals so that as many students as funds permitted are being supported in the continuance of their work. Investigations in all branches of the natural sciences are still in progress at the universities and approved institutes.

DISCUSSION

FACTORS INFLUENCING TREE DESTRUCTION DURING THE NEW ENGLAND HURRICANE

COMPARED to hurricanes in the South, the New England hurricane of September 21, 1938, was extraordinarily destructive to trees, both shade and forest, in its path. This seems all the more startling, since the great storms on the South Atlantic or Gulf coast frequently rage for 15 to 20 hours longer, while the high wind velocity of the New England catastrophe covered a period of only about 4 hours.

As it had been the privilege though not the pleasure of the writer to witness, at various times, five different hurricanes in the southern states, the contrast between the results of these so far as trees are concerned and those of the northern hurricane of last fall seemed the more striking and stimulated interest in determining the factors which may have been responsible for the greater tree damage in New England.

In the great Caribbean pine areas in South Florida, which were comparatively untouched by turpentining or lumbering, the great hurricane of 1928 did not affect the contour of these woods, as seen from a distance, to any great extent. True, there were trees blown over here and there, but there was not the picture of annihilation that was represented by the New England woods after the hurricane.

Apart from the obvious thought that the forests of the South, buffeted so frequently by great storms, represent the survival of the fittest to endure these conditions, there are six factors which seem paramount in explaining the greater susceptibility of the northern trees to the gale. These are here enumerated.

(1) *Extremely high wind velocities in local areas.* During the storm there were local gusts of great intensity, taking everything before them, the largest and strongest trees as well as the weakest. There are very few weather instruments in New England for the recording of gust velocities, but the Blue Hill Observatory recorded a gust of about 187 miles per hour and on Mt. Washington, 163 miles per hour. These compare with the strongest gusts of the southern storms. Over the broad path of the hurricane, however, the storm crushed the weak trees, the strong surviving.

(2) *The type of tree prevalent.* This undoubtedly had some bearing. The hard pines of the South are more gale-resistant than the white pines, Norway spruces, willows, poplars, locusts and soft maples of the North. In New England the types of trees standing the storm best were sycamores, oaks, old well-rooted elms and sugar maples, and beech.

(3) *Tree ages.* The age class was very important. The very youngest (under 20 years for white pines, under 30 for hardwoods) and the very oldest survived the gale. The younger trees were more supple, giving with the wind, and were comparatively better anchored in the soil by the tap root, while the very oldest trees were tougher, had deeper and stronger root systems and, due to natural branch spacing, offered less resistance to the wind in their tops. Casualties were greatest in the age range of 30 to 90 or 100 years. Inasmuch as a number of our dominant trees, such as white oak, hemlock and white pine, are known to exceed 500 years in age, a 100-year-old tree may be considered as "young."

(4) *Man-made conditions.* This was an important factor not only in regard to shade trees, but to woodlands as well. Cutting of roots of shade trees in construction of sewers, pipe lines, curbings and the like, thus depriving trees of anchorage, was probably the one most important factor in the destruction of street trees. The loss of shade trees on lawns, greens and commons by overthrow was also disproportionately great. This in many cases may be traced to the giving of lawns precedence over shade trees in regard to treatment, for example—the application of fertilizer for the benefit of the grass over the surface, which tended to stimulate surface root growth of trees, resulting in shallow root systems, poor anchorage and consequent wind-throw.

The nature of the woodlands in the path of the hurricane was important. Most of the woodlands in this area were composed of young trees, usually about 20 to 60 years old, an age range very susceptible to wind damage. This condition had resulted from the excessive and constant cutting of older trees for lumber and fuel. On the other hand, in many places near manufacturing centers, woods were repeatedly cut for fuel when scarcely double the size of broomsticks and, interestingly enough, these young sprout growths under 20 years of age were little damaged by the storm.

Just as the wind damage is greatest in the pine woods of the South, where the trees have been weakened structurally by turpentining or thinning out by lumbering, the destruction to New England woods was greatest where lumbering and thinning had taken place, and to sugar maple groves which had been weakened from various sources, ultimately traceable to the activities of man.

(5) *Insect and fungus trouble to trees.* There has been in many parts of the hurricane area during the past few decades excessive defoliation of shade trees by insects, such as the gipsy moth, elm leaf beetle and cankerworms. The cumulative result of years of this damage was decided weakening of the trees. Borers and bark beetles gained a foothold leading to infection by wood rot fungi. A large proportion of the hurricane-damaged trees had been structurally weakened by borers and wood rot fungi, prior to the storm.

(6) *Soil conditions.* Tree damage was particularly

great where hardpan or underlying rock restricted root growth, while the wetness of the soil due to four days of rain prior to the storm was an important factor in weakening the anchorage of shallow-rooted trees.

There has been a lesson to be gained from the hurricane by every one interested in trees. While New England may not be visited again by so great a storm for another hundred years or more, the factor of wind destruction to trees is always with us to a greater or lesser extent and the planting of sturdy varieties and proper care of our valuable shade trees should lessen and restrict to a considerable degree storm damage in the future.

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THE POINT OF ORIGIN OF THE BLOSSOM-INDUCING STIMULUS[1]

THE use of such techniques as grafting,[2] defoliation and the exposure of different parts of the plant to unlike photoperiods[3] has given rise to the belief that a "flower-forming hormone" originates in the foliage near the tip of the plant. The classical experience of inducing plants to flower by girdling would suggest that the leaves may not be the exclusive means of control of the blossom-inducing stimulus.

To observe the response of some plants to the transfer of the flower-forming substance by grafting, flowering and non-flowering plants of *Cosmos sulphureus* var. Klondike, morning glory, var. Heavenly Blue, *Petunia,* poinsettia, soybean var. Biloxi, stock (*Matthiola incana*) var. Xmas pink, tobacco var. Maryland Mammoth and *Xanthium echinatum* were grafted by the approach method, a modified tongue being used. Positive results were secured with morning glory, *Petunia,* soybean and *Xanthium,* the "donor"[3] plants stimulating the "receptors" to produce blossoms. The state of growth of the plants as well as the cultural environments appear to affect the results secured from grafts. For example, deflorating the *Xanthium* donors increases their influence. Flowering was not initiated by grafting in the case of plants of *Cosmos,* poinsettia, stock and tobacco.

It appears that a successful transfer of the flower-forming stimulus by a graft contact depends upon whether the species being used will give a systemic or local response to a photoperiod treatment of only a part of the plant. Exposure of a part of a morning glory, *Petunia,* soybean or *Xanthium* plant to the proper environment induces flowering throughout the plant. *Cosmos,* poinsettia[4] and tobacco, on the other hand, give local responses, as the part being exposed to the proper photoperiod comes to flower and the remainder stays vegetative.

The older receptor branches of *Petunia* in a warm environment blossomed in short days before the younger donor branches which were exposed to long days. That is, it appears that the presence of flowers is not essential to the functioning of branches as donors of the stimulus to flower.

Poinsettia and tobacco plants were induced to blossom in a warm, short-day location, contrary to their habit,[5] by the application of a current of cool air to a short length of the stem some three to four inches below the tip of the plant. These species were also stimulated to blossom in warm, short days by wrapping a taut rubber band about the stem a few nodes below the tip to constrict it.

The variable responses to grafting and to donor branches depending upon the flowering habit of the species and the effects of a "temperature girdle" and banding in causing blossoming indicate that the stem of the plant plays a part in the appearance of blossoms as well as does a leaf-formed hormone-like substance.

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ON DESLOTHING THE SLOTH

DURING several visits to Panama and while making other observations, the possibility of raising the level of activity of the sloth made an interesting appeal. Considered academically and also to test the action of certain substances or conditions, this animal makes an excellent subject. Its basal level of movement is exceedingly low, and increments may readily be observed. Other features make it almost ideal for study, including its ease of handling and training and the plentiful supply in the tropics. Tests were made on both two-toed and three-toed species, the experimental work having been carried out mainly at Barro Colorado Island Laboratory, Canal Zone, and Gorgas Memorial Laboratory, Panama. It may be said that several ways were found of speeding up their activities.

Recognition that the body temperature of the sloth is normally much lower than that of other mammals suggested a temperature test. Mere exposure to the tropical sun for an hour or two raised the rectal temperature 4° or 5°, and thereupon the activity of the animal became much greater. This was evidenced by its rate of travel along the under side of a twelve-foot horizontal pole, timed by stop-watch. Again, setting up an emotional reaction in the sloth, by simple feints and passes before it, augmented its speed very markedly. Extract of the adrenal cortex made in this labo-

[1] Published with the approval of the director of the Agricultural Experiment Station.

[2] M. Ch. Cajlachjan, *Compt. Rend. Acad. Sci. U. R. S. S.,* 18: 606–612, 1938.

[3] K. C. Hamner and J. Bonner, *Bot. Gaz.,* 100: 388–431, 1938.

[4] R. H. Roberts, J. E. Kraus and N. Livingston, *Jour. Agr. Res.,* 54: 319–343, 1937.

[5] R. H. Roberts and B. E. Struckmeyer, *Jour. Agr. Res.,* 56: 633–678, 1938.

ratory, when given in moderate doses (5 cc or so every hour or two), also provided an adequate stimulus to increased activity. Two other substances, adrenalin and prostigmin, were also found to be effective in raising the sloth from its (anthropomorphically considered) sluggardy. Several other preparations which were tested over several days (thyroid and pituitary, also benzedrine and strychnine solutions) gave negative results.

Raising the body temperature appeared to be the best stimulator; on the average the increments in rate of walking on warming approximated 50 per cent., and several cases showed increases of over 100 per cent. Cortico-adrenal extract was observed to maintain the increased rate of upside-down travel by the sloth for some ten or twelve hours after injection. This is in keeping with the earliest observations on the influence of the cortical hormone in augmenting activity.[1] Prostigmin as well as emotional excitement appeared to bring out the fighting instinct in sloths, along with the greater ability to "run" away.

The rate of progress of the sloth may be given interestingly on a mileage basis. It appeared from several hundred tests that the two-toed sloth normally averaged a little over three hours to the mile, and three-toed animals almost four-and-a-half hours. The slowest individual tardigrades, however, took over six hours for the distance. Under excitation such as that noted above, the mile was possible in about two hours, and in a burst of speed by one animal only, a mile an hour was accomplished.

It is likely that in the wild the higher rates of progress indicated would not obtain, because of difficulties of arboreal travel, lack of stimulus, etc. In some cases the sloth rests, indeed, for weeks on end, in the same place in the same tree. Beebe has written very engagingly on its habits.[2] It may be recalled that the sloth possesses only about one half the amount of muscle (percentally) found in other mammals, and that about one quarter of its weight is made up of stomach and contents—both serious handicaps to fast movement.[3] The present observations indicate, nevertheless, that several fairly effective methods of deslothing the sloth may be employed.

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[1] E. Eagle, S. W. Britton and R. F. Kline, *Am. Jour. Physiol.*, 102: 707, 1932.

[2] W. Beebe, *Zoologica*, 7: 1, 1926.

[3] S. W. Britton, R. F. Kline and H. Silvette, *Am. Jour. Physiol.*, 123: 701, 1938.

SCIENTIFIC BOOKS

PHYSIOLOGY

Physiology of the Nervous System. By J. F. FULTON. London, New York, Toronto: Oxford University Press, 1938. Pp. xv + 675.

IN this extensive work the author has pursued his declared intention of serving the study of clinical medicine and of meeting the needs of the medical student. From this point of view the work has, in the main, been well done, and much valuable material for the student or clinician is included. To the reviewing physiologist, it seems that the book should rather be called "physiological anatomy." By far the greater part of the book is given to anatomical details, and indeed much of the fundamental physiology of the nervous system is so sketchily treated, with important parts of the subject omitted altogether, that a sense of unbalanced emphasis is left in the reader's mind. The entire fields of conditioned reflexes and electrophysiology—the latter a topic of rapidly expanding interest—are omitted; and, though it is explained that their omission is intentional, the book is thereby rendered an incomplete treatment of the subject indicated in the title. There are several evidences of haste in preparation, but this is to be expected in so large an undertaking by such a busy worker.

An admirable feature of the arrangement is the beginning of each chapter with a historical note and the conclusion of each with a concise, well-worded summary. The historical notes are both interesting and instructive, serving to enhance the understanding of present knowledge. The sequence of chapters, beginning with receptors, motor units and elementary reflexes and then proceeding upward through the spinal cord to the cerebrum, is logical and in the main clear, but it involves some repetition, as in the case of postural reflexes.

The author's interest lies in organization and integration, rather than in basic principles and constituent mechanisms. This is frankly stated in the following sentence (p. 71): "The problem of organization is the principal subject of the present volume; the nature of synaptic transmission, important though it always remains, must here be relegated to a few brief paragraphs." The major foundation stone of the physiology of the nervous system is that well-known but little understood event which we call the nerve impulse. There is scarcely a reference to the vast body of research which for a century has been directed to elucidating this phenomenon, and hardly a word of the results of these researches, beyond a brief, but excellent statement of the all-or-nothing principle.

The influence of the author's great teacher, Sher-

rington, is much in evidence, and indeed the chief merit in the book is the broad, philosophical view of organization and integration which emanates from that influence. The minutely detailed account of the researches on stretch reflexes and other features of spinal cord physiology, which occupied the author during his years in Sherrington's laboratory, seems to involve over-emphasis of a specialized topic at the expense of other more fundamental matters, which suffer a corresponding neglect.

In a footnote (p. 73) is described how the author once espoused a chemical theory of central nerve function and disposed of rival electrical theories with arguments which, it may be noted, failed to consider the possibility of "reverberation," which was suggested in 1923 and for which a strong case has since been made by Lorente de Nó. The footnote goes on to explain how the author has now abandoned the chemical theory and with equal vigor espoused the electrical theory, just when cogent evidence for a chemical theory is becoming well-nigh overwhelming, without even a reference to experiments which have raised almost insuperable obstacles in the way of the electrical theory.[1] He prematurely accepts the evidence of Eccles, which seemed to rule out the synaptic action of acetylcholine, but which has since been convincingly answered by the work of Rosenblueth and Simeone.[2] In support of the electrical theory he makes dogmatic assertions concerning events in the cell membrane, including reiterated insistence on the unproved assumption that an antidromic impulse causes a discharge which sweeps through the entire nerve cell. This unfortunate bias reaches a climax on page 96, where he takes up the once ignored explanation of after-discharge by reverberating circuits and then states, "it seems unnecessary to discuss alternative hypotheses."

These adverse criticisms impress a reviewer to whom the basic questions appeal as standing at the portal of rational inquiry into the mechanism of conscious life. Not being qualified to pass expert judgment on the anatomical survey, which constitutes the greater part of the book, the reviewer is impressed with the quantity of material which is marshalled to provide an understanding of integration in the nervous system.

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SPECIAL ARTICLES

MICE AS CARRIERS OF PATHOGENIC PLEUROPNEUMONIA-LIKE MICROORGANISMS

Two distinct strains of filtrable pathogenic microorganisms of the pleuropneumonia group have recently been isolated from the brains of mice and shown to possess tissue affinities of such a nature that they can produce in mice two experimental diseases which bear some resemblance to certain phases of rheumatic fever and rheumatoid arthritis in man.[1] Strain A induces a transitory, migratory polyarthritis, multiplies in the brain and in mesothelial cells of the pleura, pericardium and peritoneum, and produces a typical exotoxin which gives rise to choreiform signs. Strain B produces no such toxin, but has an almost specific affinity for the joints in which it gives rise to a chronic, progressive, proliferative, ankylosing arthritis. These two strains are biologically and immunologically distinct from each other, from *Pleuropneumonia bovum* and from pleuropneumonia-like microorganisms that have been isolated from rats in pure culture or in association with *Streptobacillus moniliformis*.[2] These findings clearly suggested the necessity of determining whether or not similar microorganisms could be isolated from patients with rheumatic fever and rheumatoid arthritis, and following this indication, Swift and Brown[3] reported the isolation of pleuropneumonia-like microorganisms from acute rheumatic fever material.

The chief purpose of the present communication is to record certain experiences which indicate the inadvisability of using mice in attempting to isolate such microorganisms from human material. While studying exudates and tissues from patients with rheumatoid arthritis or rheumatic fever, it was found that inoculation of such material, normal synovial fluid or sterile broth into the eyes (vitreous) of mice, yielded positive pleuropneumonia-like cultures with great regularity. In a typical test, material under investigation was injected into both eyes of six 3-weeks-old mice; six days later the eyes were removed with separate, sterile instruments, immersed in anesthetic ether for one to two minutes (this was sufficient to bring about adequate sterilization of the exterior of the eye), incised, and streaked across 30 per cent. ascitic fluid agar. In most instances, innumerable, typical, microscopic, pleuropneumonia-like colonies appeared within two days. With the Rockefeller Institute Swiss stock, at least four or five mice out of each group of six yielded positive cultures from one or both eyes in ten different experiments. The colonies on solid medium resembled those of Strain A; after several transfers on fluid

[1] W. B. Cannon and A. Rosenblueth, *Amer. Jour. Physiol.*, 119: 221–235, 1937.

[1] A. B. Sabin, SCIENCE, 88: 575, 1938; *ibid.*, 89: 228, 1939.

[2] E. Klieneberger, *Jour. Hyg.*, 38: 458, 1938.

[2] A. Rosenblueth and F. A. Simeone, *Amer. Jour. Physiol.*, 1938, 122: 688–707, 1938; *ibid.*, 708–721.

[3] H. F. Swift and T. M. Brown, SCIENCE, 89: 271, 1939.

medium the cultures were found to be agglutinated in high titre by anti-A serum and to produce a neurotoxin which was completely neutralized by the "A" strain antitoxin. Further studies revealed that these microorganisms were inhabitants of the external surface of the eye, from which they could be cultured with great regularity, and frequently in large numbers unassociated with any bacterial colonies. It was apparent that as a result of the intraocular injection some of these microorganisms were carried into the eye, where they multiplied in the course of a few days. Similar studies carried out with mice of the Rockefeller Institute albino stock and of another Swiss strain (Freed) originating from the Institute stock but bred elsewhere for the past six to seven years, revealed the same condition, but the carrier rate was lower; it was thus possible to encounter groups of six mice from which these microorganisms could not be obtained, while in other groups of six, either all or a varying number yielded positive cultures of the same type. Evidence was also obtained that these microorganisms inhabit the mucosa of the nose and accessory sinuses from which they may be carried into the lungs in the course of nasal instillation under anesthesia.[4] It may be of interest to note here that in one test in which six mice were given nasal instillations under ether anesthesia and intraocular injections of pericardial fluid from a patient who succumbed to acute rheumatic carditis, three different types of pleuropneumonia-like microorganisms were isolated: a Type A from the eyes, a Type B from the lungs of one mouse, and a new type (to be called "C") which produced arthritis in mice but no toxin and was immunologically distinct from all the others studied. Two pleuropneumonia-like strains producing pneumonia in mice (isolated by Dr. Dienes in the course of passaging two human rheumatic heart muscle suspensions through the lungs of mice) were submitted to me for study[5]; they were found to be immunologically identical with Strain A and to produce neurotoxin in cultures which was neutralized by "A" antitoxin. Of three cultures isolated by Drs. Swift and Brown from pneumonic lungs of mice inoculated with rheumatic fever material, one was found to be a Type A, one a Type B and the third the same as the newly isolated Type C.

It is apparent, therefore, that the presence or absence of pleuropneumonia-like microorganisms in rheumatic fever and rheumatoid arthritis exudates and tissues will have to be established primarily by cultural methods, and not by passage through mice or other animals. Using a large variety of solid and fluid media and "passaging blindly" six or more times, I have been unable thus far to grow pleuropneumonia-like microorganisms from thirteen rheumatoid arthritic exudates (twelve patients), four rheumatoid subcutaneous nodules (three patients), rheumatoid synovial tissue (two patients), acute rheumatic blood, pleural fluid, pericardial fluid and heart muscle (two patients),[6] but many more cultivation experiments will have to be performed with suitable specimens before a final decision can be reached.

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THE PREPARATION OF PITUITARY GROWTH HORMONE FREE FROM LACTOGENIC AND THYROTROPIC HORMONES

THE knowledge that the anterior hypophyseal growth hormone is comparatively stable to alkali led us to assume that this protein would be free from disulfide linkages (–S–S–) and therefore resistant to cysteine reduction. Therefore a 5 per cent. solution of growth hormone in its purest form[1] was treated with double the amount of cysteine at pH 8.0. The reduction which resulted caused a precipitation of one half the total protein, whereas the supernatant contained most of the growth hormone when tested in normal plateaued female rats. (Table 1.)

TABLE 1

RETENTION OF GROWTH HORMONE POTENCY AFTER TREATMENT OF ANTERIOR HYPOPHYSEAL EXTRACTS DAP35$_2$ AND DAP74$_1$ WITH CYSTEINE

Preparation		Daily dose of total protein	Daily dose of soluble protein	Number of rats per group	Grams grain per rat*
		mg	mg		
DAP35$_2$	Untreated	1	1	9	39
	Cysteine treated ..	1	0.43	6	39
DAP74$_1$	Untreated	1	1	12	51
	Cysteine treated ..	1	1	5	43

* Average gain of normal plateaued female rats by 17 daily injections over a period of 20 days.

We tested the above-mentioned cysteine-treated growth hormone for its lactogenic and thyrotropic activity. Up to the very high levels tested, these hormones were found to be absent.[2] (Table 2.)

[4] This finding suggests that viruses, such as that of influenza, which are passaged by nasal instillation in mice, should be cultured periodically to determine whether or not they have been contaminated by microorganisms of the pleuropneumonia group.

[5] Dr. L. Dienes informs me that he was able to isolate a similar strain by passaging normal mouse lung.

[6] I am deeply indebted to Dr. Edward F. Hartung, of the New York Post-Graduate Hospital, for supplying most of these specimens.

[1] Prepared by modification of the method published by Evans, Uyei, Bartz and Simpson (*Endocrinology*, 22: 483, 1938).

[2] As regards gonadotropic hormones: the follicle-stimulating hormone was known to be nearly completely absent from the untreated solutions, so tests for this substance were not considered necessary; inactivation of ICSH did

TABLE 2

DECREASE IN POTENCY OF LACTOGENIC AND THYROTROPIC HORMONES IN GROWTH HORMONE AFTER CYSTEINE TREATMENT

Preparation of growth hormone		Lactogenic M.E.D.* squab crop intramuscular	Thyrotropic M.E.D. squab thyroid intramuscular
		mg	mg
$DAP35_2$	Untreated	20	< 1
	Cysteine treated (total protein).	> 45	> 45
$DAP74_1$	Untreated	10	0.75
	Cysteine treated (soluble protein)	> 52	> 52

* Minimal effective dose.

From these results the following calculations can be made: 100 units[3] of untreated growth hormone contained from 5 to 10 units of lactogenic and from 100 to 150 units of thyrotropic hormone, whereas 100 units of cysteine-treated growth hormone contained less than one unit of either of these hormones.

Lactogenic, thyrotropic and gonadotropic hormones were next subjected to the same treatment with cysteine. Crude thyrotropic and gonadotropic hormones were found to be inactivated under the same conditions. The reduction of lactogenic hormone was accompanied by a precipitation. In a concentration above 0.1 per cent. this precipitation was almost quantitative, and no activity could be recovered from the precipitate or supernatant if a 40:1 ratio of cysteine to lactogenic hormone was allowed to react for two days at room temperature. Below 0.02 per cent. lactogenic hormone concentration, no precipitate was formed and no inactivation occurred under these same conditions. We are inclined to believe that the –SH form of the lactogenic hormone is as active as the native hormone and that its apparent inactivation is due only to its extremely low solubility.[4]

It has long been known that many organs which depend upon the pituitary for normal functioning may influence the body weight of animals. It is believed by others[5,6,7] that stimulation of these organs is essential for growth promotion by pituitary extracts or that growth is dependent upon synergism or addition of these effects. That the pituitary growth hormone has now been freed from two more (and possibly other of the specific stimulating hormones of the pituitar seems of the greatest importance in establishing th individuality of this hormone.[8] A more detailed analy sis of the action of cysteine on pituitary hormones an of the biological and chemical properties of the growt hormone obtained by this method will be published i the near future.

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not appear to be quite as complete as inactivation of the other hormones. It is, however, true that fifty times the M.E.D. found in the untreated solution gave only a doubtful response.

[3] Growth unit defined in reference 1.

[4] While this work was in progress, it was learned from a remark by Bates in the discussion in the Cold Spring Harbor Symposium for Quantitative Biology (1938, p. 271) that he too had observed the inactivation of lactogenic, thyrotropic and gonadotropic hormones by cysteine.

[5] O. Riddle, Sigma Xi Lectures for 1936–7, Ohio State University Symposium on Hormones, p. 450.

[6] O. Riddle, *Endocrinology*, 19: 1, 1935.

[7] O. Riddle and R. W. Bates, *Endocrinology*, 17: 689, 1934.

[8] H. M. Evans, *Proc. Assn. Res. Nerv. and Mental Di* 17: 175, 1938.

THE CAUSATIVE AGENT OF INFECTIOUS EQUINE ENCEPHALOMYELITIS IN VENEZUELA

THE writers have been engaged in the study of th causative agent of infectious equine encephalomyeliti since the year 1936, when it made its appearance i Venezuelan Goajira. In this work, particular atte tion has been devoted to the etiological angle, which i of course, of the utmost importance in the control o this disease. Some of the results obtained up to th date are briefly stated below.

(1) From the brain of animals which died of th infection in rural areas, a filterable virus has be isolated.

(2) This virus was found to be highly pathogen to guinea pigs, whatever the mode of inoculation (intr cerebral, intraperitoneal, intramuscular, subcutaneous and caused them to die in from 48 to 72 hours aft inoculation.

(3) Rabbits also proved to be very susceptible they succumbed in from 72 to 96 hours after intr cerebral inoculation.

(4) The disease could not be artificially transmitte to cattle, and this is in accordance with observatio in rural localities, where bovines are refractory to th infection.

(5) The virus, carried again into horses, induces a acute condition with a clinical and anatomopatholog picture identical with that observed in animals a tacked under natural conditions in rural areas. Fro the brain of horses thus inoculated, the original vir has been isolated.

(6) The virus is easily grown in chick embryo which die in about 18 hours following inoculation. B means of successive passages, such a concentration w achieved that dilutions of 1:5.000.000 proved leth to guinea pigs.

(7) The production of protective vaccine has be based on chick-embryo culture of the virus. Labor tory animals immunized with it withstand successfull

thousands of lethal doses, a fact which proves the efficacy of the vaccine. For three months the Laboratories of Veterinary Bacteriology and Parasitology have been supplying the Ministry of Agriculture and Animal Husbandry of Venezuela weekly with considerable quantities of this autochthonous vaccine in order to combat the disease in rural areas.

(8) To determine the immunobiological characteristics of encephalomyelitic virus isolated in this country, the following has been employed:

(a) U. S. eastern strain virus;
(b) U. S. western strain virus;
(c) vaccine made in this country from the virus under observation (autochthonous);
(d) bivalent vaccine made from U. S. eastern and western strain viruses;
(e) encephalomyelitic serum made from autochthonous virus;
(f) U. S. bivalent encephalomyelitic serum made from both eastern and western strain viruses;
(g) U. S. monovalent encephalomyelitis serum made from western strain virus;
(h) Argentine encephalomyelitic serum made from Argentine virus.

From these comparative researches, carried out both *in vivo* and *in vitro*, it is to be inferred: (1) That the Venezuelan encephalomyelitic virus is wholly different both from the American western virus and from the Argentine virus, with which it has no immunobiological connection. (2) That it also differs immunobiologically from the American eastern strain virus, with which, however, it has some connection on account of its high virulence, pathogenicity, etc. (3) That the immunizing power of the protective vaccine made from autochthonous virus surpasses by far that of the American bivalent vaccine, prepared from both eastern and western viruses. (4) That the Venezuelan encephalomyelitic serum neutralizes the corresponding specific virus, not only *in vivo*, but also *in vitro*.

(9) As a result of these studies, the causative agent of infectious equine encephalomyelitis has been isolated for the first time in Venezuela. It is assumed that the agent in question constitutes a *sui generis* strain, different from the encephalomyelitis viruses described up to now.

(10) Venezuela should be given full credit for being perhaps the first South American country where the production of encephalomyelitic vaccine from embryo-cultured virus has been undertaken.

(11) The writers are about to finish a complete report on these researches which will be published in due course.[1]

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A METHOD FOR STUDYING LIVING MOSQUITO LARVAE AND OTHER SMALL AQUATIC INVERTEBRATES

A VERY real problem in attempting to study small, living, aquatic animals under the microscope is to keep them in the field of vision without continual change of focus. The usual practices of entangling the animal in cotton threads or of treating the preparation with various drugs are generally undesirable, since the question naturally arises as to whether one is still dealing with a "normal" animal. There are, likewise, numerous objections to imprisoning the animal beneath a coverslip, because of the possible crushing of the preparation and the equally serious matter of cutting off its oxygen supply.

After numerous attempts to remedy this situation, the following very simple solution was found: A piece of thin copper wire (about No. 22 B. and S. gauge), six inches long, was bent at one end into a small circle one quarter inch in diameter, the ring of wire thus formed being made secure by several turns of the end of the wire around the stem of the loop. The other end of the wire was twisted around a small, square block of lead, such as is commonly used by histologists. The lead served as support for the wire pedicel and ring, as shown in Fig. 1.

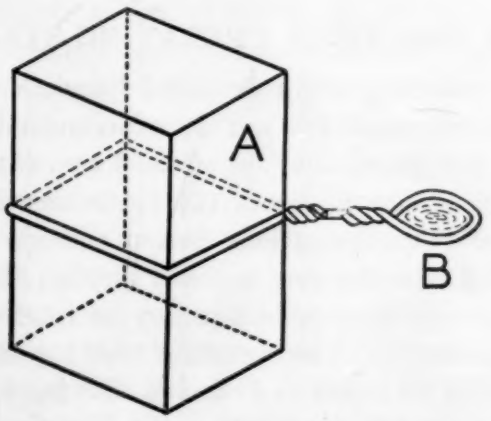

FIG. 1. Device for studying small, living, aquatic animals. *A*, lead block; *B*, wire loop with inclosed film of water.

[1] An already studied stock culture of our virus, with its virulence increased by consecutive passages through susceptible animals, has been supplied, for the sake of cooperation, to Lederle Laboratories, Pearl River, N. Y. C. E. Beck and Ralph W. G. Wyckoff, of these laboratories, published a communication on the subject in SCIENCE, 88: 2292, 530.

Now to use the device the wire ring is simply dipped into water momentarily and a film of liquid imprisoned across the ring. The animal is then placed in this film and is automatically retained therein by the action of the surface tension on the two sides. The lead weight serves to hold the ring on the stage of the compound or dissecting microscope in any position desired.

The device has the advantage of confining the animal to a small area and, essentially, to a single plane so as to eliminate the necessity of continual change of focus. The animals so far studied by this method show surprisingly little tendency to struggle, but, to the contrary, go about their feeding and regular body movements within the fluid layer in what appears to be a normal manner. Furthermore, the large area for gaseous diffusion eliminates any respiratory difficulties.

The method has proved of exceptional value in studying mosquito larvae and their relations to the surface, but, presumably, is to be recommended for vital preparations of other aquatic invertebrates. The films last for considerable lengths of time, depending, of course, upon the relative humidity of the laboratory air. A number of them were timed at over an hour. Loss of thickness due to evaporation, however, may be readily remedied from time to time by addition of a drop of water to the film without disturbing the preparation.

The film may be varied in thickness to accommodate animals of different sizes by adding more or less water with an eye-dropper or by using various sizes of wire in the loop.

A further advantage is the ability thus offered to study the ventral side of the animal by simply turning the lead block over on its other end.

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A PRACTICAL OPERATING STAND

THE operating stand described herewith was especially constructed for use in experimental surgery. The advantages of this type of stand are: (1) Low cost and ease of construction. (2) Interchangeable operating table tops for various sizes of animals. (3) The operating table top may be tilted through 180 degrees. (4) The operating table top may be rotated through 360 degrees. (5) The operating table top may be elevated from 29 inches to 45 inches allowing a sitting or standing operating position. (6) The single column allows maximum leg room and the entire stand occupies little laboratory space.

The entire column (1) is constructed of pipe and pipe rail fittings. A is a 2-inch pipe rail base, B is a piece of 2-inch pipe 20 inches long drilled and tapped at C for the locking bolt, D is a piece of 1½-inch pipe 20 inches long and E is a 1½-inch pipe rail adjustable base. The brace F and H is of strap iron and is attached to the operating table top by means of an awning bracket G.

The operating table top is of the size that will accommodate the animal being studied and is made mainly of wood, held together by strap iron. The cross section (2) shows the manner of construction. A ready means of interchanging table tops is provided by threaded lead sockets in the wood base of the top; thumb screws in these hold the top securely to the column. In use the stand is securely bolted to the floor.

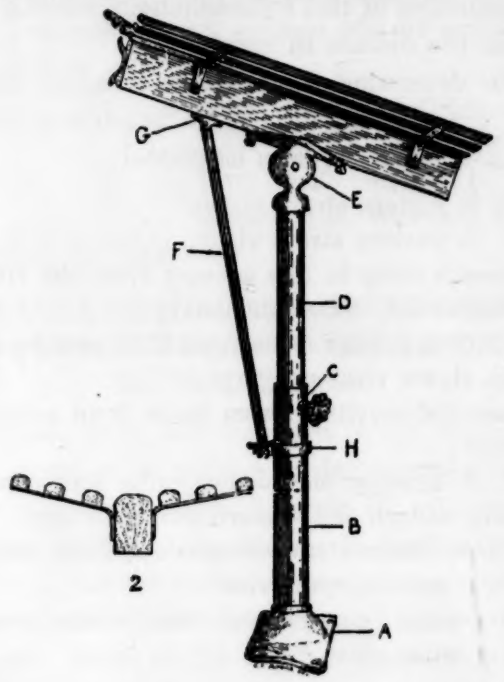

FIG. 1

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